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Memorandum

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To: Mr. Mark Kaems
Division of Maintenance
District 11, MS#56

Date: May 27, 2003

File: 11-SD-15
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EA 11 – 2326u1

From: **DEPARTMENT OF TRANSPORTATION**
DIVISION OF ENGINEERING SERVICES
Geotechnical Services
Office of Geotechnical Design – South 2, Branch D

Subject: Interstate 15 (I-15) Proposed Retaining Walls RW1, RW2, RW5 and RW6, Foundation Investigations and Geotechnical Design Report.

INTRODUCTION

Following your request, the Office of Geotechnical Design – South 2 conducted a geotechnical investigation for the foundation design of four retaining walls that are part of the Auxiliary/Added Lanes project in San Diego, California. Our investigation consisted of a site reconnaissance, review of archived reports (files) and geologic literature, limited geologic mapping, subsurface investigation, laboratory testing, engineering analysis, and the writing of this report. Along with your request, we have received from you the proposed structures layouts and cross-sections that were used in our fieldwork, engineering analyses, and for this report purpose.

PROJECT LOCATION

For the project location and its limits, reference is directed to Figure 1, Project Location. The project site is located in the City of San Diego, California. It generally involves the section of I-15 between the Scripps Poway Parkway Undercrossing and the offramp from northbound I-15 to Ted Williams Parkway (From Station 291+29 to 316+40).

GENERAL

Table 1 on the following page lists the proposed structures, and indicates their limits (stations) and maximum heights. All walls are planned to by Type 1 retaining walls constructed according to the Caltrans Standard Plans – B3-1 (Standard Plans, 1999). For detailed locations of the proposed walls, reference is directed to Figures 2-1 through 2-6.

Table 1

WALL No.	BEGIN STATION	END STATION	ALIGNMENT	MAXIMUM HEIGHT (m)	MAXIMUM HEIGHT AT STATION
RW1	295+66	298+48.1	SD15	3.055	298+40
RW2	292+20.2	298+48.3	SD15	3.352	298+48
RW5	305+18.1	307+22.7	SD15	2.3	305+76
RW6	300+50.4	301+02.5	SD15	3.606	300+50

GEOLOGY

The project site lies within the Peninsular Ranges Geomorphic Province of California. The project area is generally underlain by artificial fill that is underlain by a Mesozoic igneous basement. The basement, which upper layer is weathered, is composed of upper Jurassic Santiago Peak Volcanics (Kennedy and Peterson, 1975).

The Santiago Peak Volcanics rocks range in composition from basalt to rhyolite, but are predominantly dacite and andesite. They include a variety of breccia, agglomerate, volcanic conglomerate, and fine-grained tuff-breccia. In addition, they include a number of small plutons of mildly metamorphosed gabbro. The Santiago Peak Volcanics are hard and extremely resistant to erosion and form topographic highs. Most of the volcanic rocks are dark greenish gray where fresh, but weather grayish red to dark reddish brown. The residual soil developed on the Santiago Peak Volcanics has the color of weathered rock and supports the growth of dense chaparral.

During the construction (grading) of the freeway, cutting operations exposed the Santiago Peak Volcanics rocks (basement) in cuts and derived materials for the construction of fill road embankments. Therefore, artificial fill consists of compacted earth materials derived from local sources, mainly cuts in the Santiago Peak Volcanics basement.

SEISMICITY

The project site is located within a seismically active region of southern California. However, no known Holocene fault exists within the project area. The nearest known active fault is the Newport-Inglewood-Rose Canyon West Fault Zone believed to be capable of producing an earthquake with a Maximum Credible Magnitude of 7.0 on the Richter scale. It is located about

16 km southwest and west from the project site. The La Nacion Fault is located about 19 kilometers south from the project limits, and it is capable of producing an earthquake with a Maximum Credible Magnitude of 6.75 on the Richter scale. In addition, the Whittier-Elsinore Fault lies about 40 km northeast from the project limits, and it is capable of producing an earthquake with a Maximum Credible Magnitude of 7.5 on the Richter scale. All three aforementioned faults are believed to be capable of generating a Peak Ground Acceleration of about 0.25 g at the project site (Mualchin and Jones, 1990; Mualchin, 1996).

SURFACE AND SUBSURACE INVESTIGATIONS

Our field surface investigations consisted of, several site inspections, photo-documentation, and limited geologic 1:1000-scale mapping at the locations of the proposed retaining walls. For photographs of the locations of the proposed structures, reference is directed to Attachment 4, Photos.

The subsurface investigation program was conducted by the Southern California Soil and Testing (SCST) consultant in accordance with the Caltrans (District 11) Contract No. 11A0713, Task Order No.4. It consisted of advancing five borings, utilizing Hollow Steam Auger to depths ranging from 6.2 m to 7.6 m below the ground surface. Boring locations are shown on Figures 2-1 through 2-6. During the drilling, Standard Penetration Tests (SPT) were performed at selected depth intervals. Based on SPT blow counts, the generalized geotechnical parameters of the subsurface soils were established. Boring logs are presented in Attachment 1, Logs of Test Borings.

GROUNDWATER

No groundwater was encountered during the subsurface investigation of 2003. In addition, in the course of our geologic mapping we inspected embankment fill slopes and found no evidence of any seepage or perched water conditions. Therefore, we conclude that no groundwater exists at the locations of the proposed walls. However, at the location of the retaining Wall RW5, shallow perched water condition or seepage could be encountered, especially during rainy season.

GEOLOGIC HAZARDS

Based on our experience in the area, our surface investigation, the subsurface investigation conducted by the SCST consultant, and the review of geologic literature, no historical and/or potential geologic hazards (e. g., landslides, slope instability, liquefaction, expansive soils, and faulting) are known to exist at the project site.

SLOPE STABILITY ANALYSIS

Since the overall stability of slopes to be retained by Walls RW1, RW2, and RW6 was of our concern, slope stability analyses were performed using the STEDwin 2.5, a computer program.

For the analyses, we utilized the geotechnical fill parameters interpreted from the site subsurface investigation and presented in Table 2, on page 5. The analyses were conducted on the most representative cross-section for Wall RW6 obtained from Caltrans' design drawings. That cross-section, at Station 300+50, represents the most adverse condition from the overall slope stability standpoint. The analyses searched for the most critical failure surfaces. Based on our analyses, the calculated Modified Bishop Safety Factor for proposed wall RW6 is 1.43, which is considered acceptable. The maximum height of Walls RW1 and RW2 is less than the height of Wall RW6 at Station 300+50. Therefore, given that all geotechnical parameters and factors are the same, the factor of safety for Wall RW6 applies for Walls RW1 and RW2 as well. The slope stability analysis data and results are presented in Attachment 2.

CORROSION EVALUATION

During the subsurface investigation soil samples from selected borings were obtained and submitted to Caltrans District 11 Materials Laboratory for corrosion analyses. Laboratory tests results indicated that none of the samples was corrosive according to Caltrans standards. Therefore, soils at the locations of the proposed walls are deemed non-corrosive. Laboratory test results are presented in Table 2 below.

Table 2, Corrosion Tests Summary

LOCATION	pH	MINIMUM RESISTIVITY (ohm-cm)	SULFATE CONTENT (ppm)	CHLORIDE CONTENT (ppm)
RW1-B1	8.7	2000	N/A	N/A
RW2-B1	8.6	2100	N/A	N/A
RW2-B2	8.2	1500	N/A	N/A

SITE CONSIDERATIONS, SUBSURFACE SOIL CONDITIONS, AND FOUNDATION RECOMENDATIONS

During the construction of I-15 the native soils above the freeway grade were cut as either a through cut or side (hill) cut, and the areas below the grade were built up as fill embankments. Also, depending on topography, offramps, onramps, connectors, approach, and departure embankments were either cut into the existing native soils or built up as fills. Fill materials generally originated from the nearby native soils cuts. It is our understanding that during the grading of the freeway, fill materials were placed and compacted to 90 % Relative Compaction in accordance with CTM 216. In addition, at the location where the Penasquitos Creek crossed the freeway alignment, the bridge was built.

During the surface and subsurface investigations, two geotechnical units that underlie the alignments of the proposed retaining walls were encountered: fill materials, and weathered bedrock of the Santiago Peak Volcanics. Based on our experience in the area, the subsurface and surface investigations (SPT blow counts), we have established generalized fill parameters that were used in our foundation analyses. They are listed in Table 2 below. Since walls RW1, RW2, and RW6 are planned to be located at the faces of relatively steep slopes, their foundation analyses (bearing capacities) were based on Hansen's Method (Bowles, 1992). Given that weathered bedrock is deemed geotechnically competent unit, its parameters are not included in Table 2.

Table 2, Geotechnical Units Parameters

GEOTECHNICAL UNIT	COHESION (KPa)	ANGLE OF INTERNAL FRICTION (degree)	MAXIMUM DRY DENSITY (KN/m^3)
Existing Fill	4.8	33	19.0
Structural Fill/Backfill	9.6	33	20.4

Retaining Wall RW1

Site Considerations

For the location of the proposed Retaining Wall RW1 (Table 1) reference is directed to Figure 2-1. Wall RW1 will be 282.143 m long and 3.055 m in maximum height. It is proposed to be a Type 1 standard wall. From Station 295+66 to 298+48.145, Wall RW1 will parallel northward the eastern shoulder of the northbound I-15. This interval represents a road embankment built of fill materials. The maximum height of the embankment is about 19 m. Along this interval, the east-facing embankment slope descends at a an inclination of 1:1.5 (V:H) (Attachment 4, Photos 1, 2, and 3). Based on a layout and cross sections provided by your office, the subject road embankment is to be widened to accommodate additional lanes. The widening will involve the placement of the proposed Wall RW1 at about the face of the aforementioned embankment slope.

Subsurface Soil Conditions

Our surface mapping and subsurface investigation conducted by the SCST consultant (Boring RW1-B1) revealed that the road embankment along the alignment of the proposed Wall RW1 consists of fill materials. At the base of the embankment, we expect fill materials to be underlain by the weathered bedrock of the Santiago Peak Volcanics. Fill consists of a mixture of gravel and cobble-size rocks of the Santiago Peak Volcanics origin, sandy silt, and sand. Locally fill grades to intensely gravelly and cobbly (with oversized rocks present). Based on SPT blow counts, the relative density of fill granular materials was found to be medium dense. Fill geotechnical engineering parameters are presented in Table 2. However, during the subsurface exploration several zones/layers composed of gravel and cobble-size rocks within relatively loose silty and sandy matrix were encountered.

Foundation Conclusions and Recommendations

From a geotechnical engineering standpoint, based on the results of the subsurface investigation, the heterogeneous embankment fill materials under the footing of the proposed Wall RW1 are not suitable for the foundation purpose. Therefore, we recommend that along the wall alignment, the 1.2 m thick layer of fill materials be removed and replaced with structural backfill as shown on Figure 3, Walls RW1, RW2, and RW6: Typical Foundation Improvement Section. This structural backfill should be benched into the existing slope in accordance with Caltrans Standard Specifications and compacted to 95% Relative Compaction in accordance with CTM 216. In addition, Wall RW1 backfill should be compacted in accordance with the Standard Specifications to 95 % Relative Compaction. The Structural Backfill material, when compacted to 95 % of Relative Compaction should yield strength parameters no less than those shown for structural backfill in Table 2.

The foundation of the proposed Wall RW1 will be embedded in structural backfill. Based on a footing embedment depth of 0.9 m and foundation width of 1.9 m we have calculated an allowable bearing capacity of 150.7 Kpa. The 1:1.5 (H:V) slope configuration descending away from about the toe of the wall and a minimum 1.5 m horizontal distance from the top outward edge of the footing to the face of the descending slope were also factored into the calculations. Additionally, the fill geotechnical parameters indicated in Table 2 were used in calculations. The allowable soil bearing capacity is based on a safety factor of 3.0 for dead plus live loads. Per the 1999 Standard Plan B3-1 (Standard Retaining Wall Type 1), the design (applied) toe pressure for a 3.0 m maximum high wall and Case I Loading (level plus 11.5 KPa surcharge) is 120 KPa. Therefore, the embankment fill materials, upon foundation improvement, will provide adequate bearing capacity for the proposed wall, and the Standard Plan Design Wall Type 1 may be used for Wall RW1.

Based on the result of the slope stability analyses for Wall RW6 we conclude that the acceptable Modified Bishop Safety Factor for the overall stability of 1.43 applies to the embankment slope after Wall RW1 is constructed.

Along the alignment of Wall RW1, the surficial layer of the existing east-facing embankment slope consists of at least 80 % of oversized rocks (by weight). That makes the 1: 1.5 (V:H) inclined slope face resistant to erosion. However, the implementation of the foundation improvement recommendations for Wall RW1 will result in a removal of that rocky protective layer from the section of the existing slope that is adjacent to planned Wall RW1. Since structural backfill is inherently susceptible to erosion, and the final slope inclination is to be 1:1.5 (V:H), we recommend that a section of the slope depicted on Figure 3 (Walls RW1, RW2, and RW3: Foundation Improvement Section) have a permanent erosion protection designed by the Caltrans Landscape Architect.

Retaining Wall RW2

Site Considerations

For the location of the proposed Retaining Wall RW2 (Table 1) reference is directed to Figure 2-2. Wall RW2 will be 628.135 m long and 3.352 m in maximum height. It is proposed to be a Type 1 standard wall. From Station 298+48.337 to 292+20.202, Wall RW2 will parallel southward the western shoulder of the southbound I-15. This interval represents a road embankment built of fill materials. The maximum height of the embankment is about 23 m. Along this interval, the west-facing embankment slope descends at a an inclination of 1:1.5 (V:H) (Attachment 4, Photos 4, 5, and 6). Based on a layout and cross sections provided by your office, the subject road embankment is to be widened to accommodate additional lanes. The widening will involve the placement of the proposed Wall RW2 at about the face of the aforementioned embankment slope.

Subsurface Soil Conditions

Our surface mapping and subsurface investigation conducted by the SCST consultant (Borings RW2-B1 and RW2-B2) revealed that the road embankment along the alignment of the proposed Wall RW2 consists of fill materials. At the base of the embankment, we expect fill materials to be underlain by the weathered bedrock of the Santiago Peak Volcanics. Fill consists of a mixture of gravel and cobble-size rocks of the Santiago Peak Volcanics origin, sandy silt, and sand. Locally fill grades to intensely gravelly and cobbly (with oversized rocks present). Based on SPT blow counts, the relative density of fill granular materials was found to be medium dense. Fill geotechnical engineering parameters are presented in Table 2. However, during the subsurface exploration several zones/layers composed of gravel and cobble-size rocks within relatively loose silty and sandy matrix were encountered.

Foundation Conclusions and Recommendations

From a geotechnical engineering standpoint, based on the results of the subsurface investigation, the heterogeneous embankment fill materials under the footing of the proposed Wall RW2 are not suitable for the foundation purpose. Therefore, we recommend that along the wall alignment, the 1.2 m thick layer of fill materials be removed and replaced with structural backfill as shown on Figure 3, Walls RW1, RW2, and RW6: Typical Foundation Improvement Section. This structural backfill should be benched into the existing slope in accordance with Caltrans Standard Specifications and compacted to 95% Relative Compaction in accordance with CTM 216. In addition, Wall RW2 backfill should be compacted in accordance with the Standard Specifications to 95 % Relative Compaction. The Structural Backfill material, when compacted to 95 % of Relative Compaction should yield strength parameters no less than those shown for structural backfill in Table 2.

The foundation of the proposed Wall RW2 will be embedded in structural backfill. Based on a footing embedment depth of 0.9 m and foundation width of 2.2 m we have calculated an allowable bearing capacity of 150.3 Kpa. The 1:1.5 (H:V) slope configuration descending away from about the toe of the wall and a minimum 1.5 m horizontal distance from the top outward edge of the footing to the face of the descending slope were also factored into the calculations. Additionally, the fill geotechnical parameters indicated in Table 2 were used in calculations. The allowable soil bearing capacity is based on a safety factor of 3.0 for dead plus live loads. Per the 1999 Standard Plan B3-1 (Standard Retaining Wall Type 1), the design (applied) toe pressure for a 3.6 m maximum high wall and Case I Loading (level plus 11.5 KPa surcharge) is 135 KPa. Therefore, the embankment fill materials, upon foundation improvement, will provide adequate bearing capacity for the proposed wall, and the Standard Plan Design Wall Type 1 may be used for Wall RW2.

Based on the result of the slope stability analyses for Wall RW6, we conclude that the acceptable Modified Bishop Safety Factor for the overall stability of 1.43 applies to the embankment slope after Wall RW2 is constructed.

Based on our field inspections, it appears that a sizable mid section of the freeway interval planned to be widened with the use of Wall RW2 does not need a retaining structure, for in lieu of a wall, grading may be implemented to provide for a 1:2 (V:H) fill slope.

Along the alignment of Wall RW2, the surficial layer of the existing west-facing embankment slope consists of at least 80 % of oversized rocks (by weight). That makes the 1: 1.5 (V:H) inclined slope face resistant to erosion. However, the implementation of the foundation improvement recommendations for Wall RW2 will result in a removal of that rocky protective layer from the section of the existing slope that is adjacent to planned Wall RW2. Since structural backfill is inherently susceptible to erosion, and the final slope is to be inclined at 1:1.5 (V:H), we recommend that a section of the slope depicted on Figure 3 (Walls RW1, RW2, and RW3: Foundation Improvement Section) have a permanent erosion protection designed by the Caltrans Landscape Architect.

Retaining Wall RW5

Site Considerations

For the location of the proposed Retaining Wall RW5 (Table 1) reference is directed to Figure 2-5. Wall RW5 will be 204.52 m long and 2.3 m in maximum height. It is proposed to be a Type 1 standard wall. From Station 305+18.18 to 307+22.7, Wall RW5 will parallel to the north the eastern shoulder of the onramp from Poway Road to northbound I-15. This interval represents cut in bedrock built of the Santiago Peak Vocanics. At this interval, the existing cut slope is generally west-facing and 25 m in maximum height (Attachment 4, Photo 7). The slope inclination varies from 1:2 to 1:1.5 (V:H). It is our understanding that the proposed Wall RW5 is to retain planned cuts in the slope in order to widen the aforementioned ramp.

Subsurface Soil Conditions

Our surface mapping and subsurface investigation conducted by the SCST consultant (Boring RW5-B1) revealed that the proposed Wall RW5 alignment is underlain by weathered bedrock of the Santiago Peak Volcanics. This section of the onramp from Poway Road to northbound I-15 was constructed as a side cut of the generally west-facing slope. The cut resulted in the exposure of the Santiago Peak Volcanics on the face of a cut slope and in the roadway section of the onramp. The Santiago Peak Volcanics Formation is regarded as a geotechnically competent unit. It consists of weathered and fractured basaltic rocks. In boring RW5-B1, the Santiago Peak Volcanics Formation was encountered at about an elevation of 125 m. However, at the location of Wall RW5 alignment we expect it to be at higher elevation.

Foundation Recommendations

From a geotechnical engineering standpoint, based on the fact that the alignment of the proposed Wall RW5 is underlain by the geotechnically competent unit, the subsurface conditions along the alignment of Wall RW5 are suitable for the design and construction of the proposed Type 1 retaining wall supported on a spread footing. Therefore, it is our recommendation that the Standard Plan Retaining Wall Type 1 design be used for Wall RW5.

Retaining Wall RW6

Site Considerations

For the location of the proposed Retaining Wall RW6 (Table 1) reference is directed to Figure 2-6. Wall RW6 will be 52.171 m long and 3.6 m in maximum height. It is proposed to be a Type 1 standard wall. From Station 300+50.409 to 301+02.580, Wall RW6 will parallel to the northeast the eastern shoulder of the offramp from northbound I-15 to Poway Road. This interval represents a road embankment built of fill materials. The maximum height of the embankment is about 12 m. Along this interval, the about east-facing embankment slope descends at a an inclination of 1:1.5 (V:H) (Attachment 4, Photo 8). Based on a layout and cross sections provided by your office, the subject road embankment is to be widened to accommodate additional lanes. The widening will involve the placement of the proposed Wall RW6 at about the face of the aforementioned embankment slope.

Subsurface Soil Conditions

Our surface mapping and subsurface investigation conducted by the SCST consultant (Boring RW6-B1) revealed that the road embankment along the alignment of the proposed Wall RW6 consists of fill materials. At the base of the embankment, we expect fill materials to be underlain by the weathered bedrock of the Santiago Peak Volcanics. Fill consists of a mixture of gravel and cobble-size rocks of the Santiago Peak Volcanics origin, sandy silt, and sand. Locally fill grades to intensely gravelly and cobbly (with oversized rocks present). Based on SPT blow counts, the relative density of fill granular materials was found to be medium dense.

Fill geotechnical engineering parameters are presented in Table 2, on page 4. However, during the subsurface exploration several zones/layers composed of gravel and cobble-size rocks within relatively loose silty and sandy matrix were encountered.

Foundation Conclusions and Recommendations

From a geotechnical engineering standpoint, based on the results of the subsurface investigation, the heterogeneous embankment fill materials under the footing of the proposed Wall RW6 are not suitable for the foundation purpose. Therefore, we recommend that along the wall alignment, the 1.2 m thick layer of fill materials be removed and replaced with structural backfill as shown on Figure 3, Walls RW1, RW2, and RW6: Typical Foundation Improvement Section. This structural backfill should be benched into the existing slope in accordance with Caltrans Standard Specifications and compacted to 95% Relative Compaction in accordance with CTM 216. In addition, Wall RW6 backfill should be compacted in accordance with the Standard Specifications to 95 % Relative Compaction. The Structural Backfill material, when compacted to 95 % of Relative Compaction should yield strength parameters no less than those shown for structural backfill in Table 2.

The foundation of the proposed Wall RW6 will be embedded in structural backfill. Based on a footing embedment depth of 0.9 m and foundation width of 2.2 m we have calculated an allowable bearing capacity of 150.3 Kpa. The 1:1.5 (H:V) slope configuration descending away from about the toe of the wall and a minimum 1.5 m horizontal distance from the top outward edge of the footing to the face of the descending slope were also factored into the calculations. Additionally, the fill geotechnical parameters indicated in Table 2 were used in the calculations. The allowable soil bearing capacity is based on a safety factor of 3.0 for dead plus live loads. Per the 1999 Standard Plan B3-1 (Standard Retaining Wall Type 1), the design (applied) toe pressure for a 3.6 m maximum high wall and Case I Loading (level plus 11.5 KPa surcharge) is 135 KPa. Therefore, the embankment fill materials, upon foundation improvement, will provide adequate bearing capacity for the proposed wall, and the Standard Plan Design Wall Type 1 may be used for Wall RW6.

For Wall RW6, slope stability analyses were performed using the STEDwin 2.5, a computer program. For the analyses, we utilized the geotechnical fill parameters interpreted from the site subsurface investigation and presented in Table 2. The analyses were conducted on the most representative (the most adverse) cross-section at Station 300+50. Based on our analyses, the calculated Modified Bishop Safety Factor for proposed wall RW6 is 1.43, which is considered acceptable. The slope stability analysis data and results are presented in Attachment 2.

Along the alignment of Wall RW6, the surficial layer of the existing east-facing embankment slope consists of at least 80 % of oversized rocks (by weight). That makes the current 1: 1.5 (V:H) inclined slope face resistant to erosion. However, the implementation of the foundation improvement recommendations for Wall RW6 will result in a removal of that rocky protective layer from the section of the existing slope that is adjacent to planned Wall RW6. Since structural backfill is inherently susceptible to erosion, and the final slope inclination is to be

1:1.5 (V:H), we recommend that a section of the slope depicted on Figure 3 (Walls RW1, RW2, and RW3: Foundation Improvement Section) have a permanent erosion protection designed by the Caltrans Landscape Architect.

Any questions or comments regarding this report should be directed to the attention of Jeff Tesar at (858) 467-2716 (Calnet 734-2716), at the Office of Geotechnical Design-South 2, Branch D.

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FIGURES

1. Figure 1, Project Location
2. Figure 2-1, Wall RW1
3. Figure 2-2, Wall RW2
4. Figure 2-5, Wall RW5
5. Figure 2-6, Wall RW6
6. Figure 3, Walls RW1, RW2, and RW6: Typical Foundation Improvement Section

ATTACHMENTS

1. Attachment 1, Logs of Test Borings
2. Attachment 2, Wall RW6, Slope Stability Analysis
3. Attachment 3, Photos

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4. Chenney and Chaassie, Soils and Foundations, NHI Course No. 13212, 1993.

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